



INTEGRATED HELMET AUDIO VISUAL SYSTEM FINAL REPORT BRIEFING

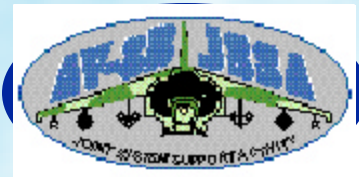


Joint Strike Fighter Office

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PROBLEM STATEMENT



- Increased information – optimize presentation to pilot
 - Present technology is limited by aircraft-fixed head-up displays (HUD)
- Future weapons provide off-boresight employment envelope
 - Air intercept missile
 - High speed anti-radiation missile (HARM) Block 6
 - Joint direct attack munition (JDAM)
 - Joint standoff weapon (JSOW)
- Increased threat drives requirement for off-boresight capability
- Precise targeting capability required



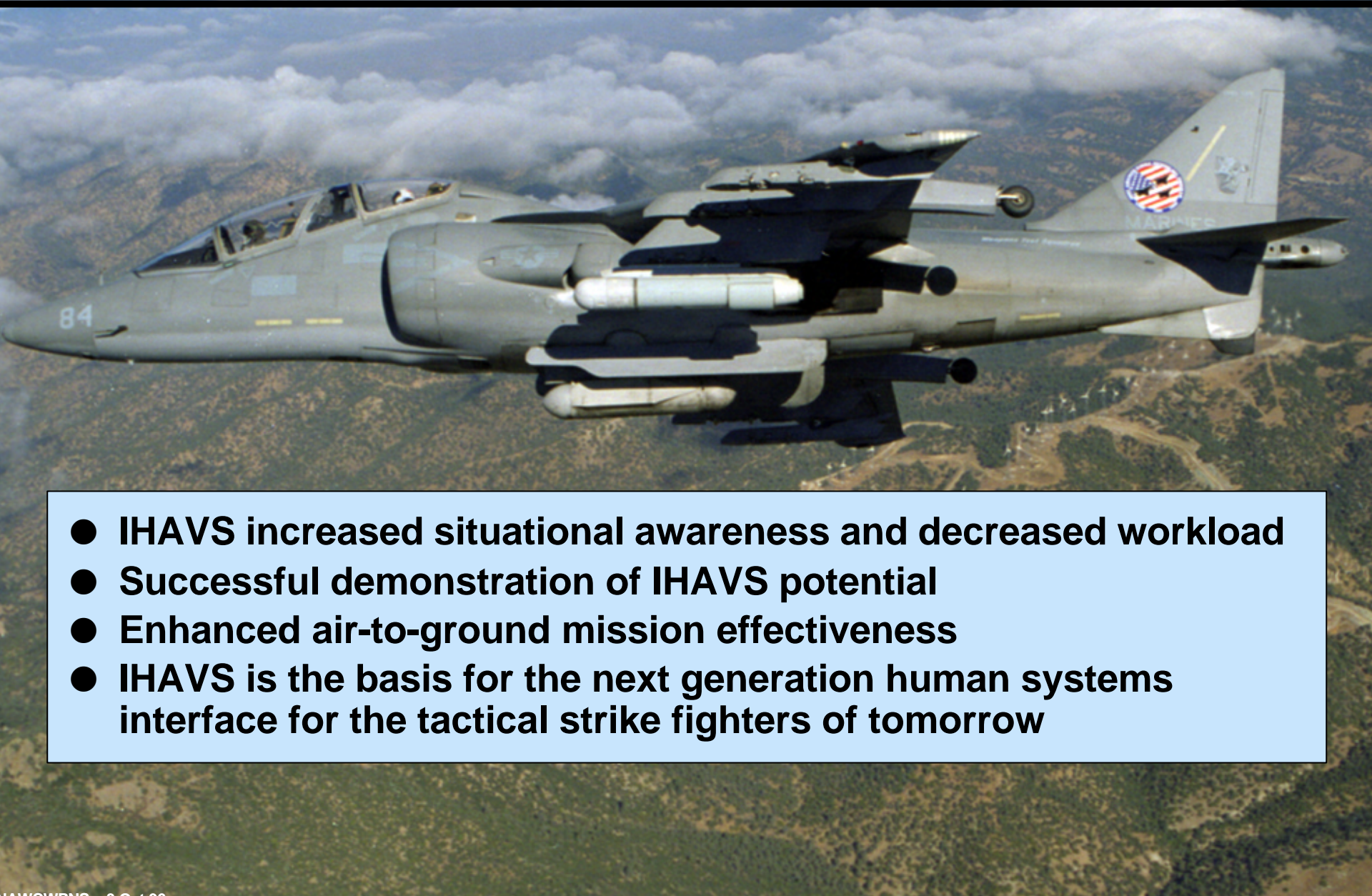
OBJECTIVES & GOALS



- Reduce workload and increase situational awareness
- Use HMD for navigation and mission tasks
- Display and evaluate sensor imagery on HMD
- Evaluate HMD weapon delivery potential
- Compare HUD vs HMD performance
- Evaluate 3-D audio threat management
- Demonstrate utility of voice interface technology
- Investigate HMD and 3-D audio designation point cueing
- Integrate the technologies into one human systems interface



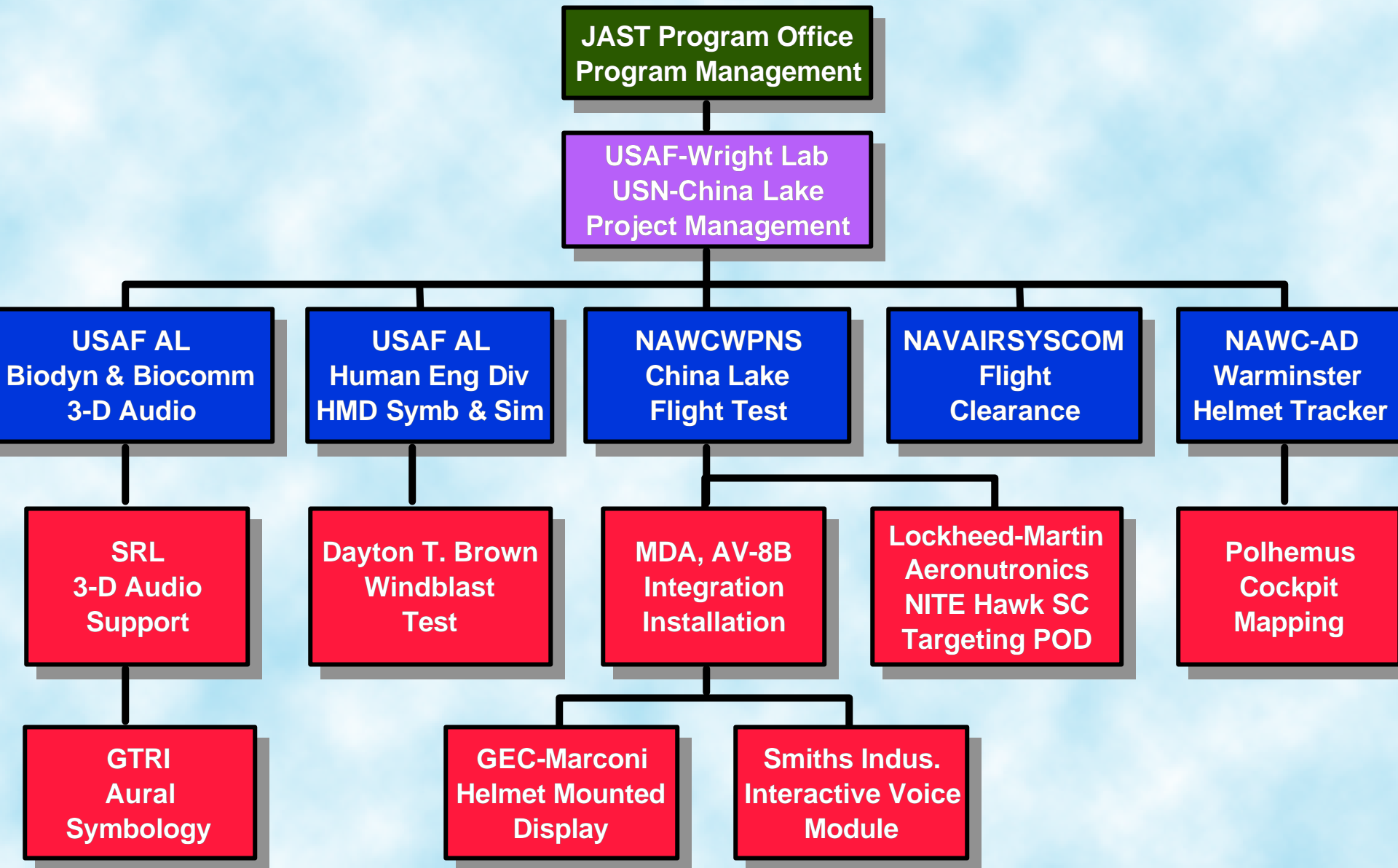
PROJECT SUMMARY



- IHAVS increased situational awareness and decreased workload
- Successful demonstration of IHAVS potential
- Enhanced air-to-ground mission effectiveness
- IHAVS is the basis for the next generation human systems interface for the tactical strike fighters of tomorrow



IHAVS PHASE 1 ORGANIZATION





SYSTEM INTEGRATION



- TAV-8B, first aircraft to incorporate IHAVS
- Integrated several technologies into one human systems interface
- IHAVS team first ever to integrate these technologies
- Significant aircraft modifications were required
- Installation was completed in 4 months, enabling system refinements to be accomplished



SYSTEM INTEGRATION



HELMET MOUNTED DISPLAY



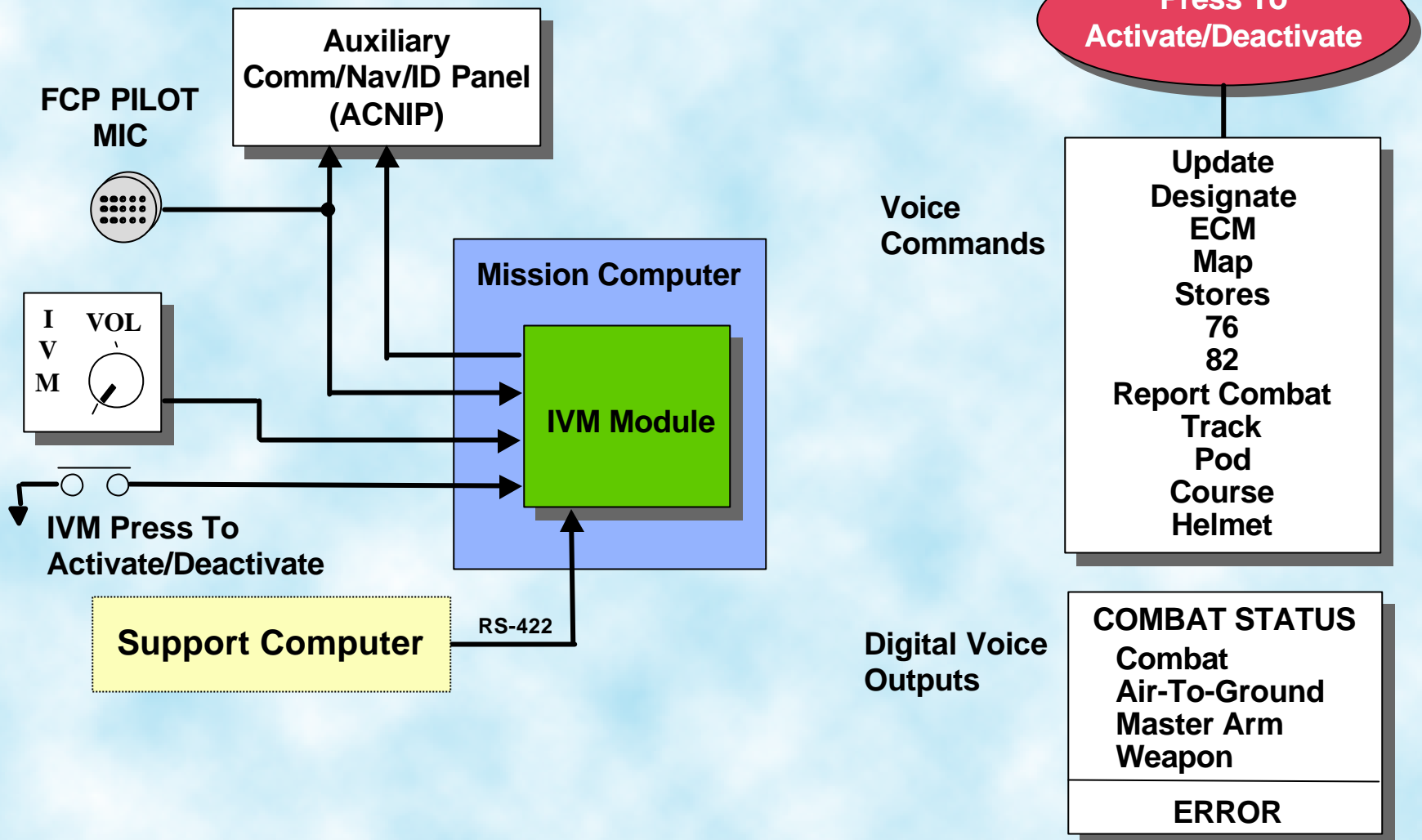
- 40° FOV, binocular, 100% optics overlap
- 24° X 24° TPOD video display capability
- On-boresight virtual HUD
 - Navigation and attack symbology
 - RWR threat symbology
- Off-boresight mode
 - Attitude, altitude and airspeed symbology
 - Targeting and look-to symbology
 - RWR threat reported at azimuth & fixed elevation



SYSTEM INTEGRATION



INTERACTIVE VOICE MODULE

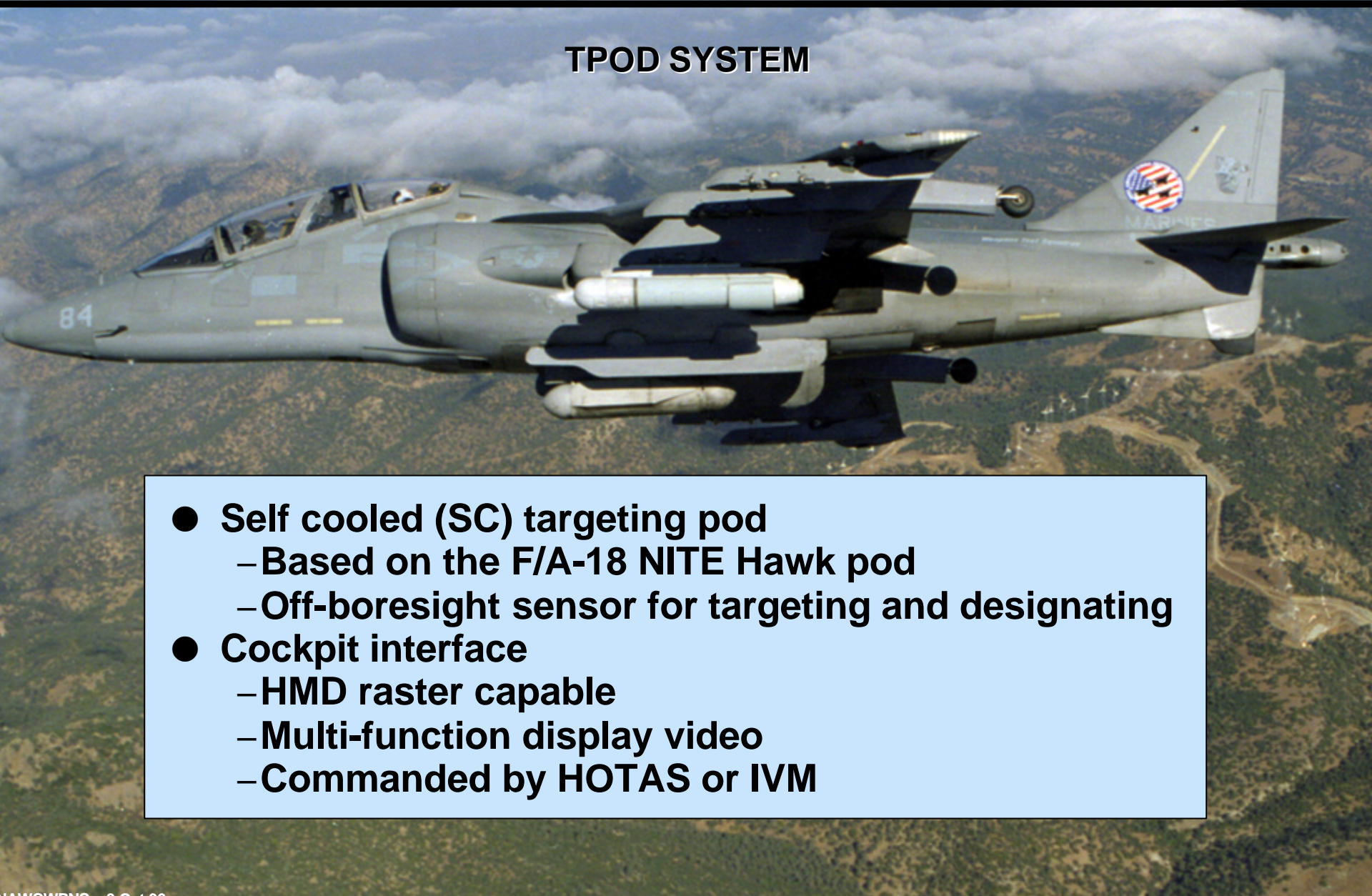




SYSTEM INTEGRATION



TPOD SYSTEM



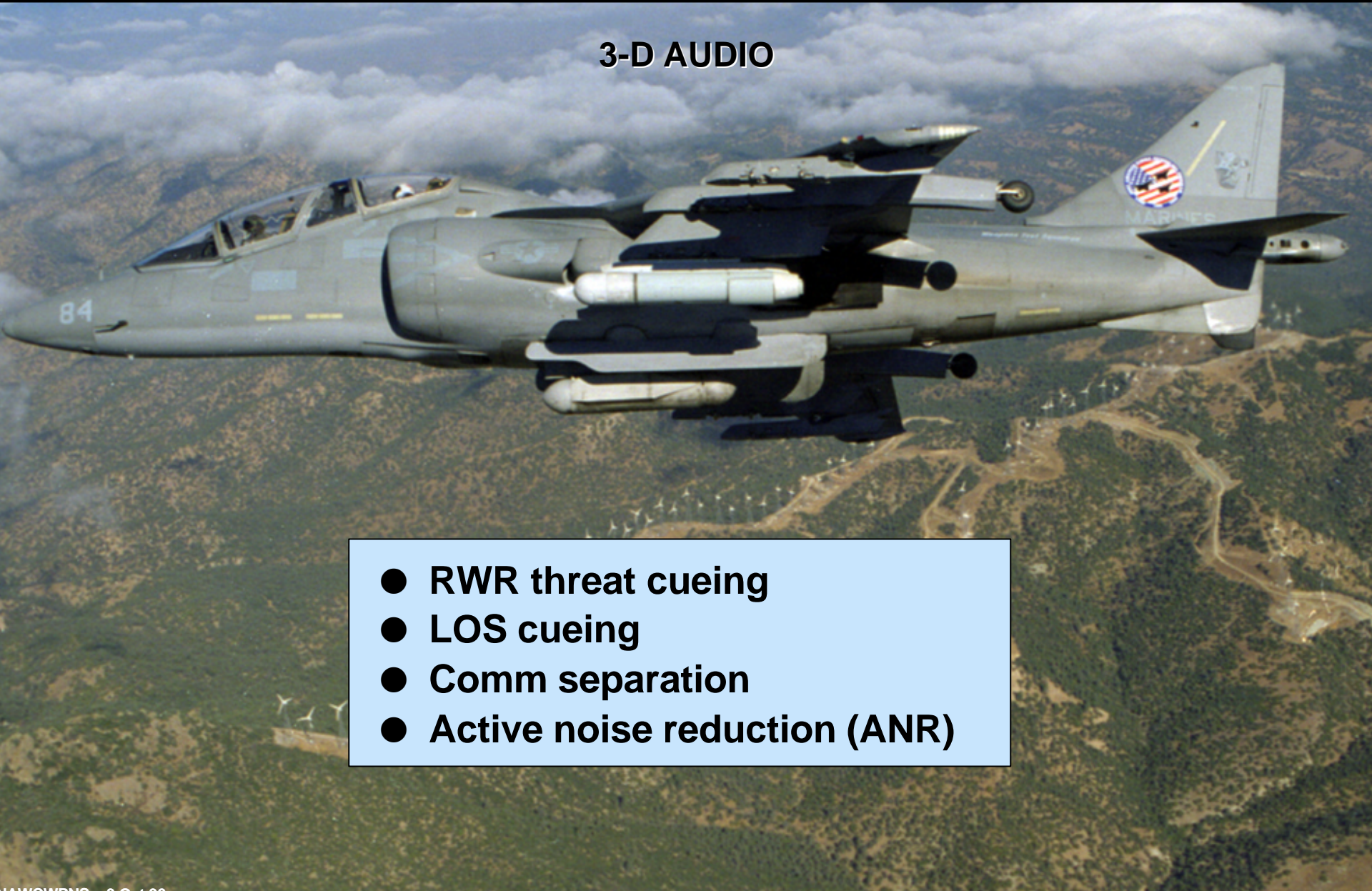
- **Self cooled (SC) targeting pod**
 - Based on the F/A-18 NITE Hawk pod
 - Off-boresight sensor for targeting and designating
- **Cockpit interface**
 - HMD raster capable
 - Multi-function display video
 - Commanded by HOTAS or IVM



SYSTEM INTEGRATION



3-D AUDIO



- RWR threat cueing
- LOS cueing
- Comm separation
- Active noise reduction (ANR)



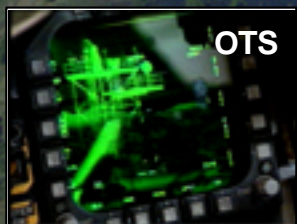
IHAVS DATA COLLECTION



HUD



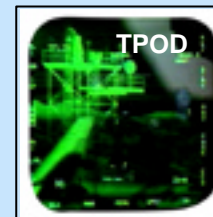
INSTRUMENTATION
POD



OTS



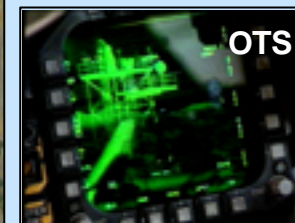
HMD



TPOD

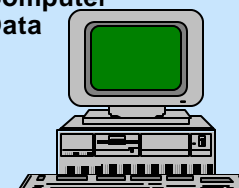


HMD



OTS

Computer
Data



LAB & GROUND TESTING

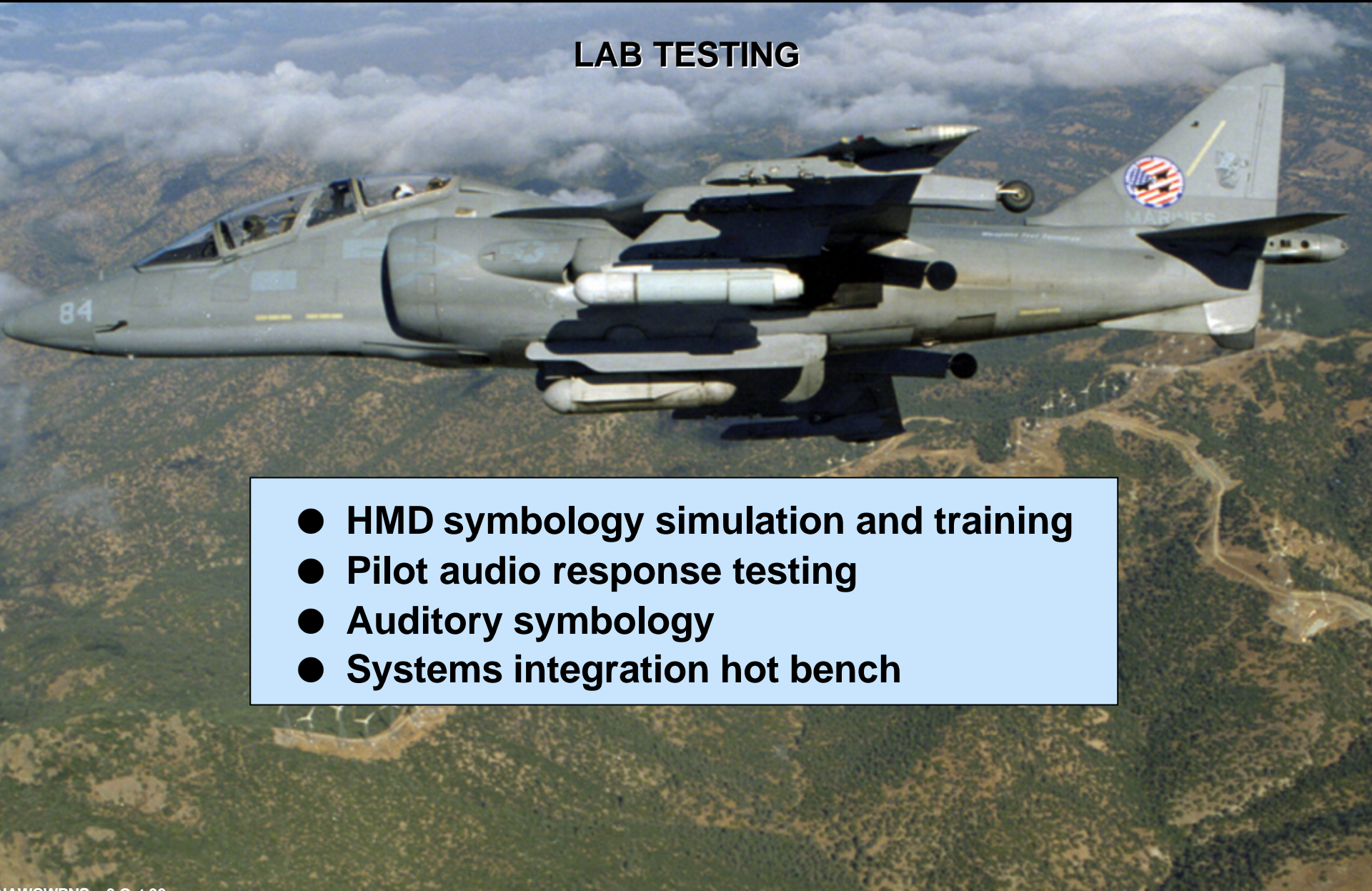




LAB & GROUND TESTING



LAB TESTING



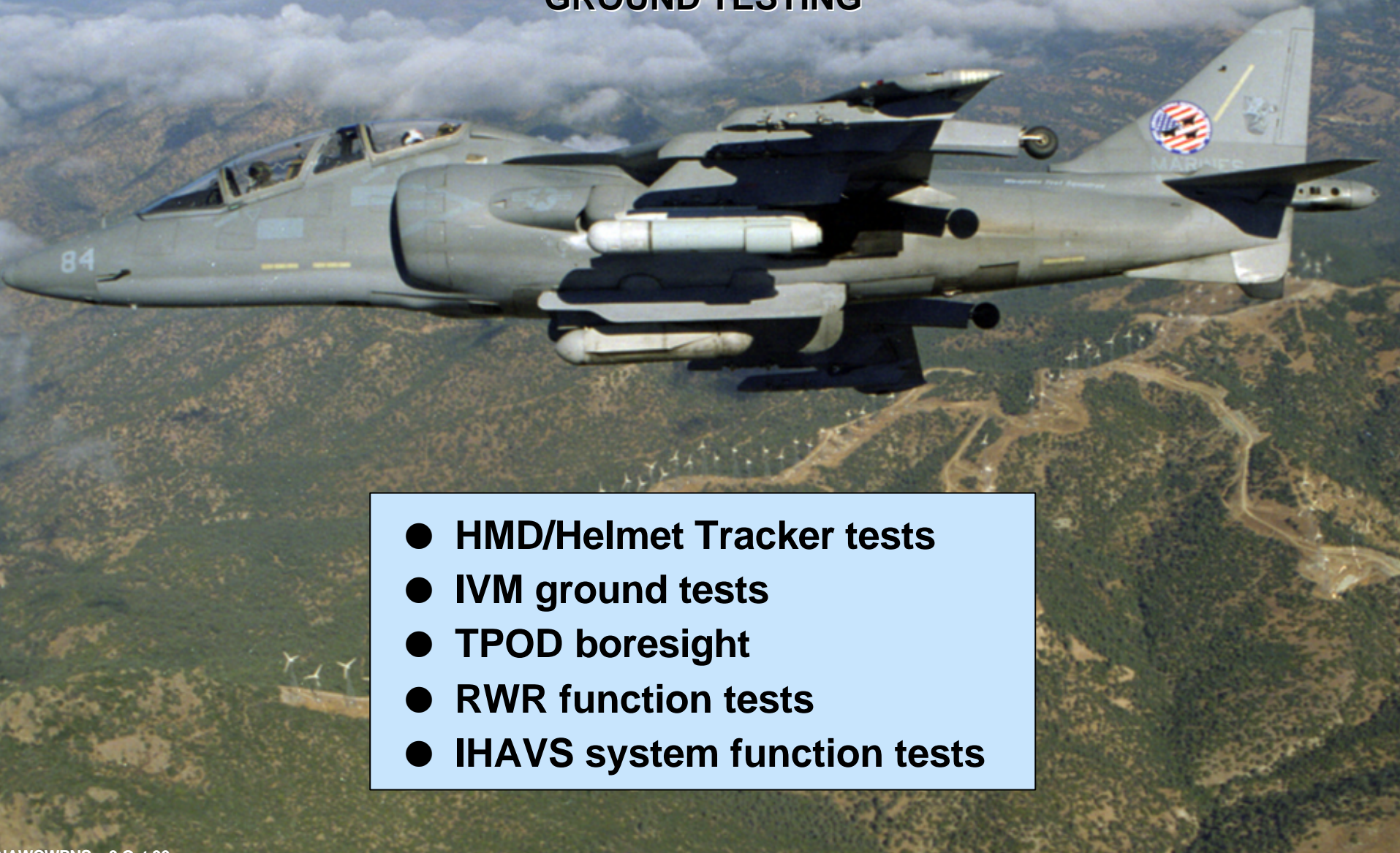
- HMD symbology simulation and training
- Pilot audio response testing
- Auditory symbology
- Systems integration hot bench



LAB & GROUND TESTING



GROUND TESTING



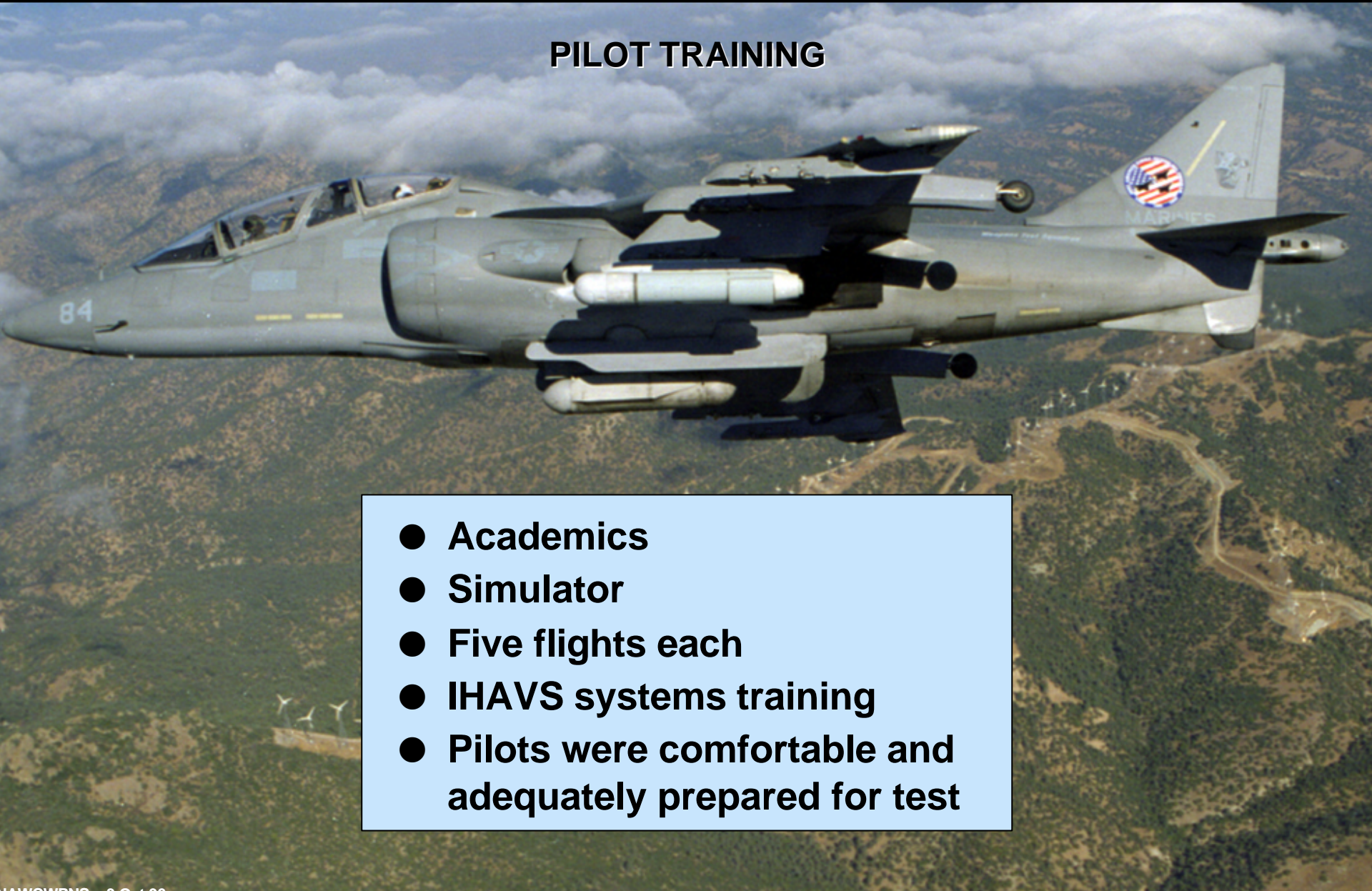
- HMD/Helmet Tracker tests
- IVM ground tests
- TPOD boresight
- RWR function tests
- IHAVS system function tests



TRAINING



PILOT TRAINING



- Academics
- Simulator
- Five flights each
- IHAVS systems training
- Pilots were comfortable and adequately prepared for test



IHAVS EMPLOYMENT



HEAD TRACKER
(provided accurate
frame of reference)

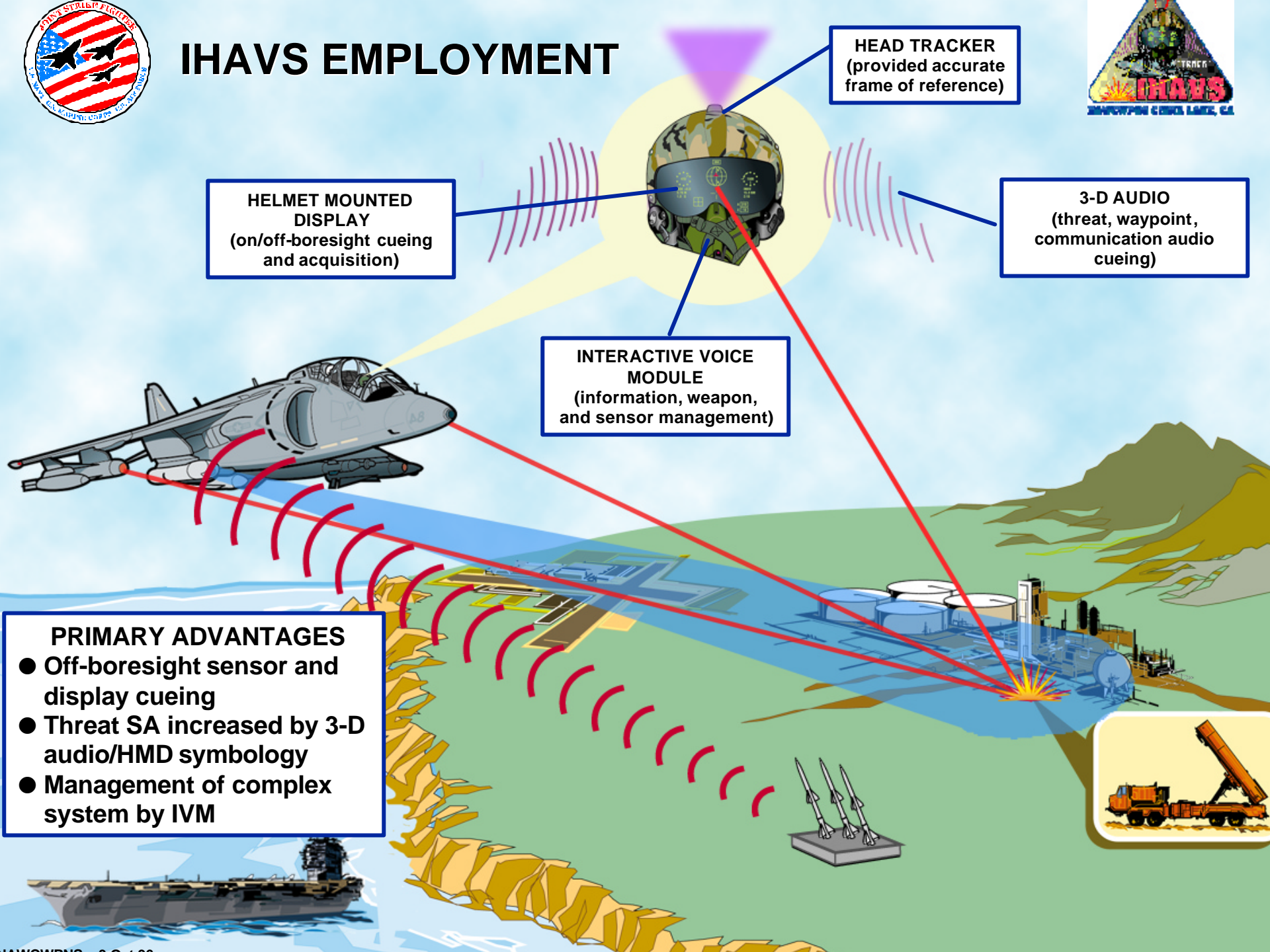
**HELMET MOUNTED
DISPLAY**
(on/off-boresight cueing
and acquisition)

3-D AUDIO
(threat, waypoint,
communication audio
cueing)

**INTERACTIVE VOICE
MODULE**
(information, weapon,
and sensor management)

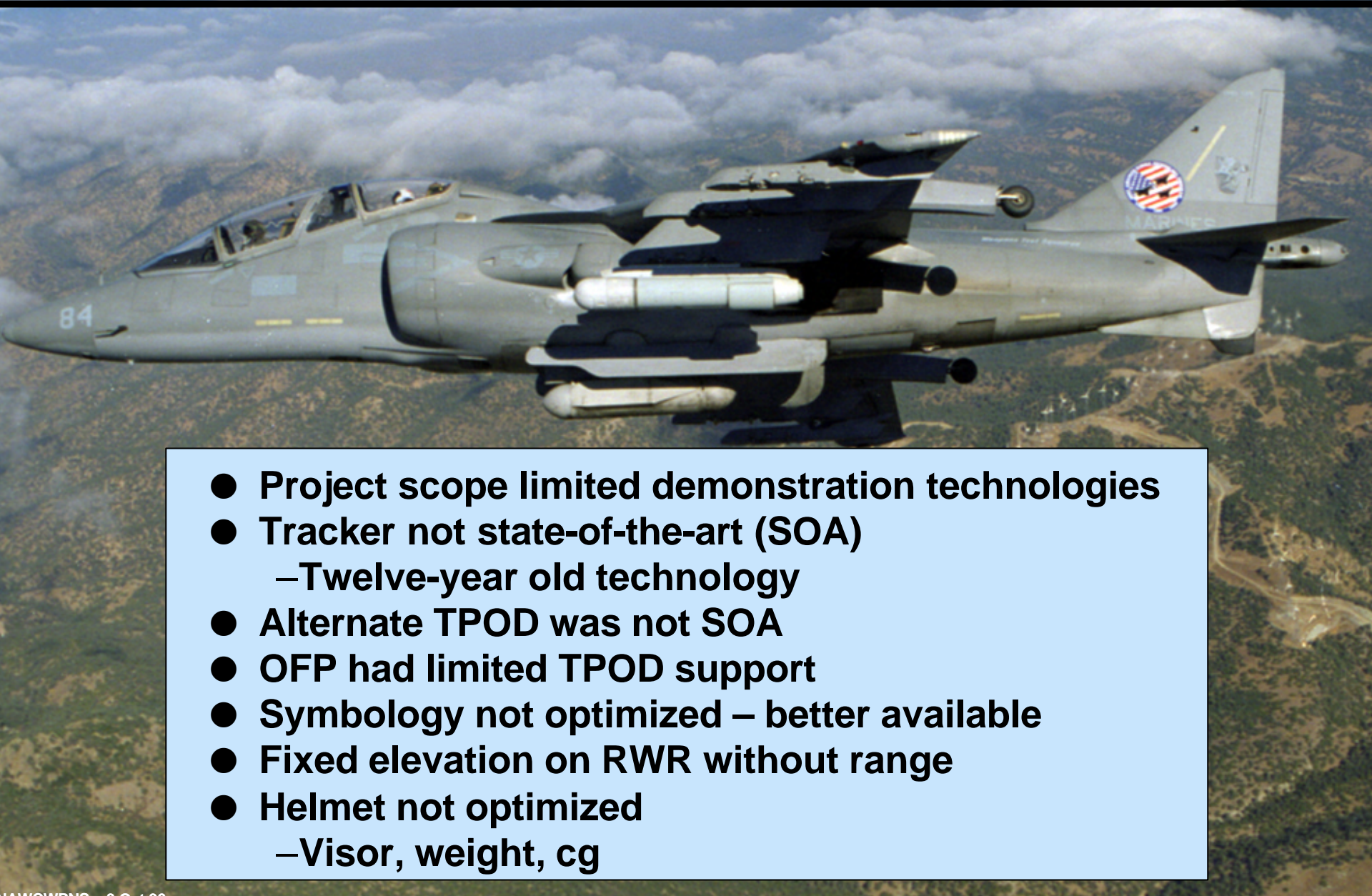
PRIMARY ADVANTAGES

- Off-boresight sensor and display cueing
- Threat SA increased by 3-D audio/HMD symbology
- Management of complex system by IVM





IHAVS LIMITATIONS



- Project scope limited demonstration technologies
- Tracker not state-of-the-art (SOA)
 - Twelve-year old technology
- Alternate TPOD was not SOA
- OFP had limited TPOD support
- Symbology not optimized – better available
- Fixed elevation on RWR without range
- Helmet not optimized
 - Visor, weight, cg



IHAVS FLIGHT TEST PLAN



IHAVS FLIGHT TEST EVENTS



Event no.	Flights	Purpose
1	1 / pilot	Aircrew Familiarization
2	1 / pilot	Non-IHAVS - Weapons Delivery (HUD)
3	1 / pilot	IHAVS System Demonstration - Weapons Delivery (HMD)
4	1 / pilot	Non-IHAVS - Tactical Ingress (HUD)
5	1 / pilot	IHAVS System Demonstration - Tactical Ingress (HMD)
6	1 / pilot	IHAVS - Tactical Ingress at Low Altitude, Pre-Planned Targets
7	1 / pilot	IHAVS - Tactical Ingress at Medium Altitude, Targets of Opportunity
8	1 / pilot	IHAVS System Demonstration - Threat Reaction

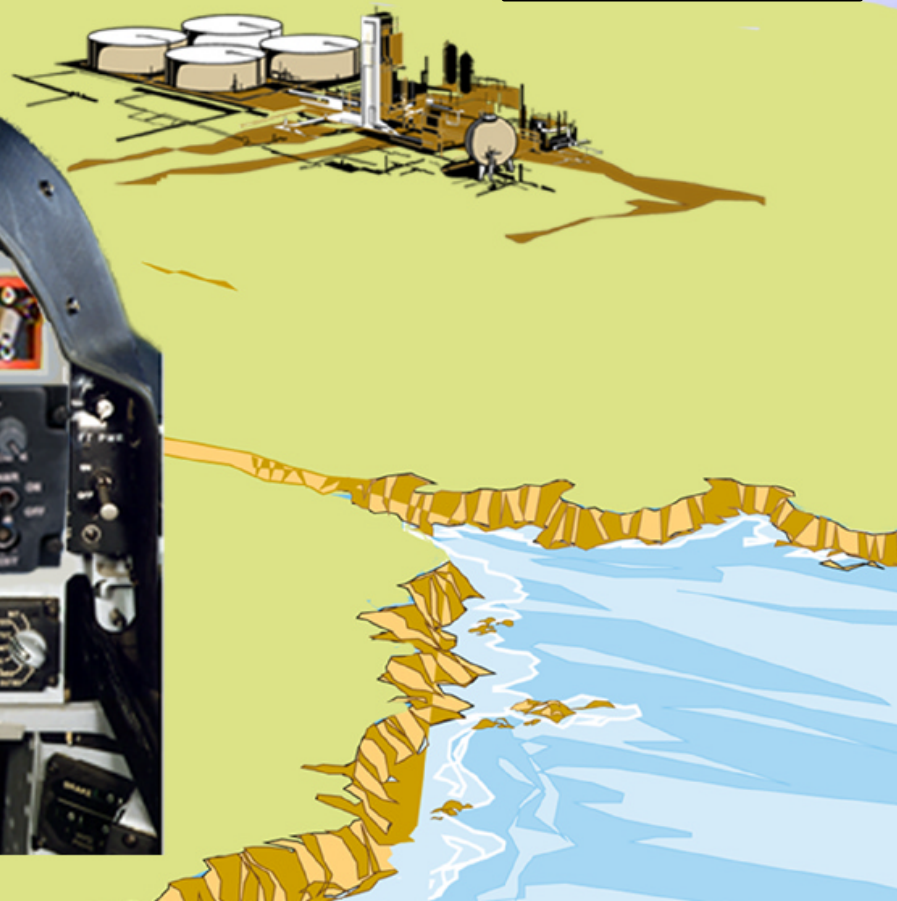


EVENT #2 NON-IHAVS – WPNS DEL (HUD)



30°DB MK 76

**4 X GAUT
- INS DESIG
2 X GCIP**





EVENT #3 IHAWS SYSTEM DEMO – WPNS DEL (HMD)



30° DB MK 76
4 X GAUT
- INS/HMD DESIG
2 X GCIP





IHAVS FLIGHT TEST PLAN



EVENT #4 NON-IHAVS – TACTICAL INGRESS (HUD)



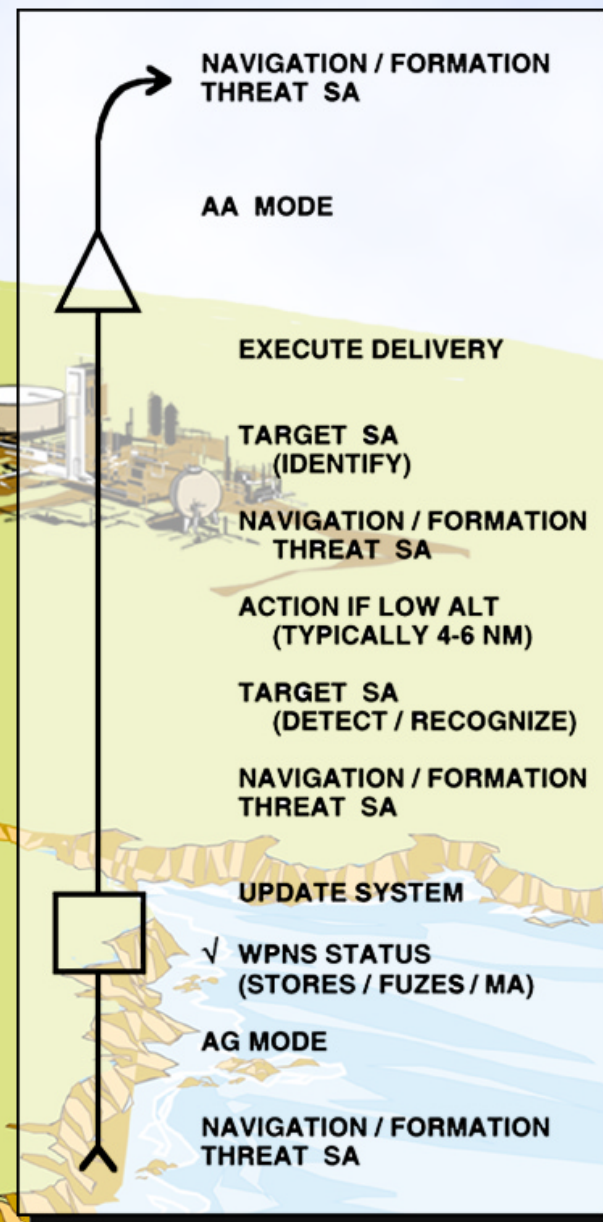
Run	System	Ingress	Target ^a	Weapon ^b	Delivery	Mode
1	NITE Hawk	Med Alt	PP: SA-2	IMAV	MAX RNG	AGM
2	NITE Hawk	Med Alt	PP: Tactical Vehicle	LMAV	MAX RNG	AGM
3	HUD	Med Alt	PP: Industrial Site	MK 82	30 deg dive	GAUT
4	HUD	Med Alt	TOO: Tactical Target	MK 82	30 deg dive	GCIP
5	HUD	Low Alt	PP: Tactical Target	Mk 82	10 deg dive	GAUT
6	HUD	Med Alt	TOO: Tactical Target	Mk 82	30 deg dive	GCIP

^aPP = pre-planned target.

^bSimulated.



NON-IHAVS – TACTICAL INGRESS (HUD)





IHAVS FLIGHT TEST PLAN



EVENT #5 IHAVS SYSTEM DEMO – TACTICAL INGRESS (HMD)



Run	Target	Weapon	Delivery	Mode
1	PP: SA-2	IMAV	MAX RNG	AGM
2	PP: Tactical Vehicle	LMAV	MAX RNG	AGM
3	PP: Industrial Site	IMAV	MAX RNG	AGM
4	PP: Tactical Target	Mk 82	30 deg dive	T-AUTO
5	PP: Tactical Target	Mk 82	30 deg dive	GAUT
6	PP: Tactical Target	Mk 82	30 deg dive	GAUT



IHAVS FLIGHT TEST PLAN



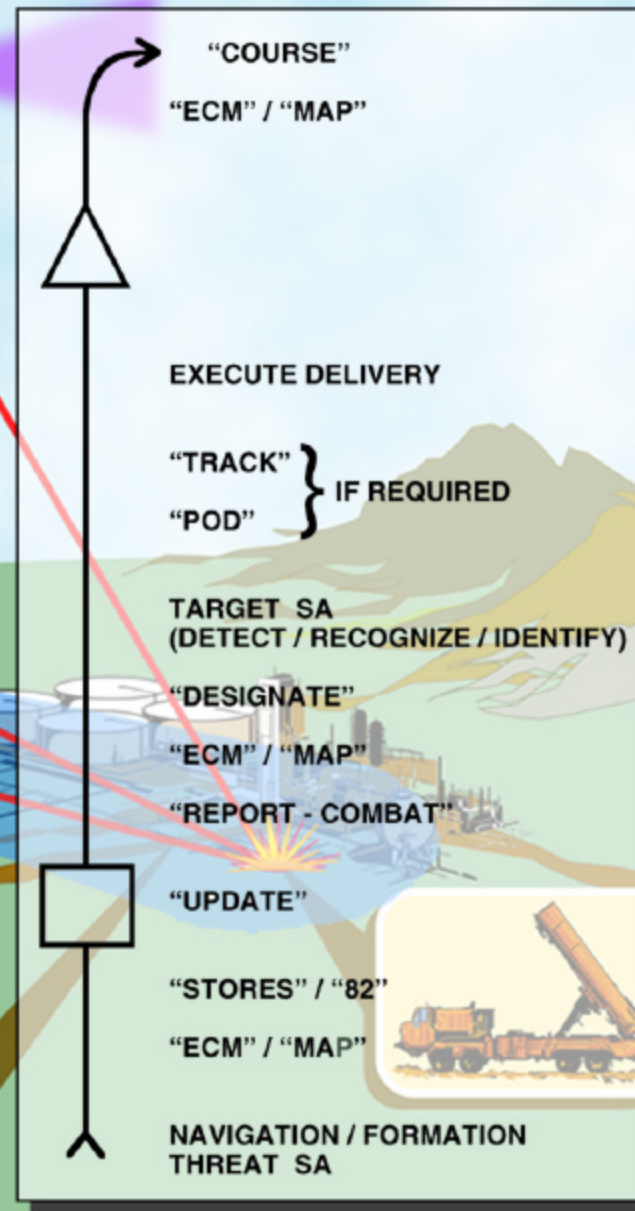
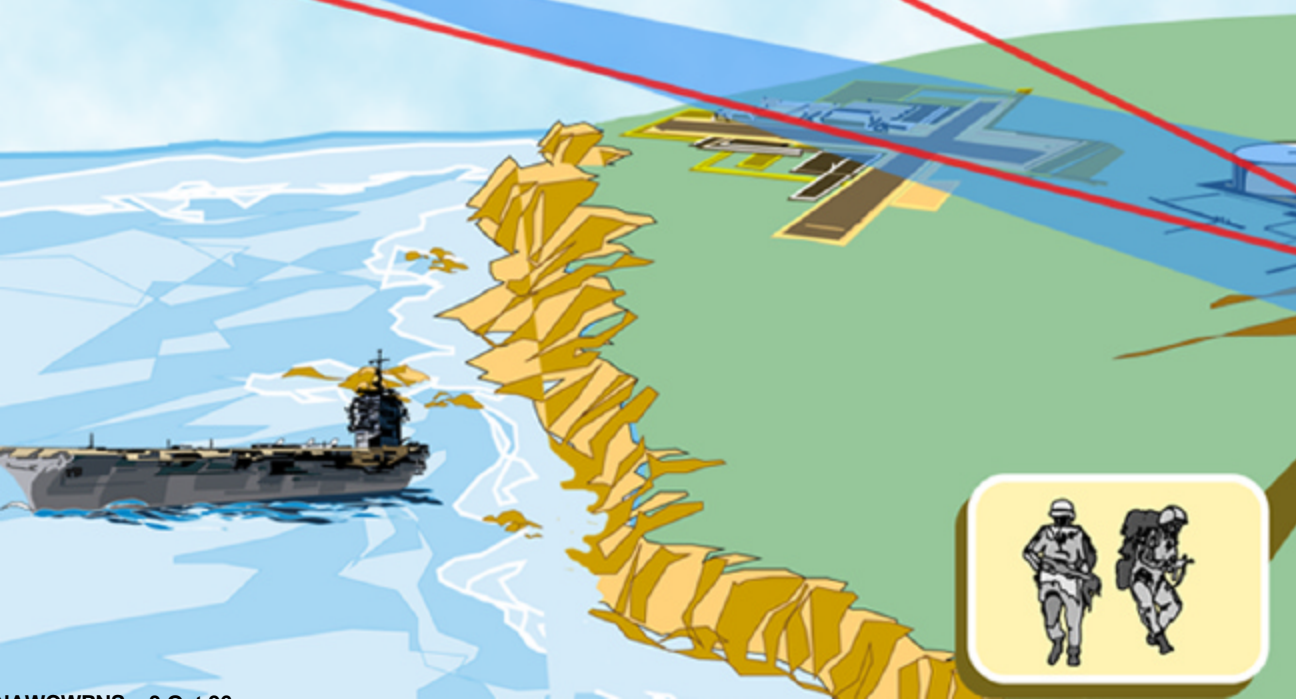
EVENT #6 TACTICAL INGRESS AT LOW ALT – PREPLANNED TGTS



Run	Target	Weapon	Delivery	Mode
1	PP: SA-2	IMAV	MAX RNG	AGM
2	PP: Tactical Vehicle	LMAV	MAX RNG	AGM
3	PP: Industrial Site	IMAV	MAX RNG	AGM
4	PP: Tactical Target	Mk 82	10-deg dive	T-AUTO
5	PP: Tactical Target	Mk 82	10-deg dive	GAUT
6	PP: Tactical Target	Mk 82	10-deg dive	GCIP



IHAVS – TACTICAL INGRESS (HMD)





IHAVS FLIGHT TEST PLAN



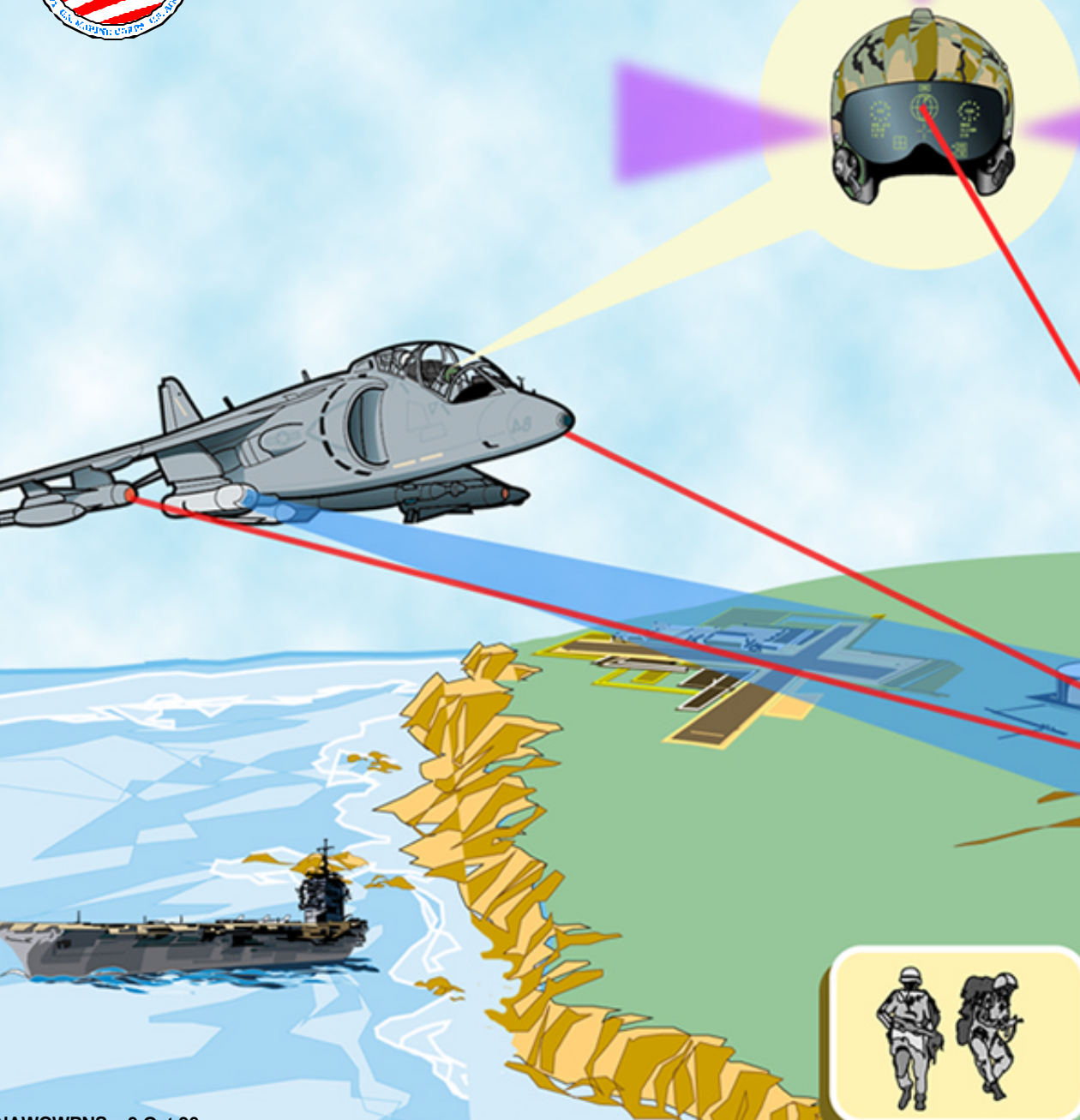
EVENT #7 TACTICAL INGRESS AT MEDIUM ALT – TGTS OF OPPORTUNITY



Run	Weapon	Delivery	Mode
1	IMAV	MAX RNG	AGM
2	LMAV	MAX RNG	AGM
3	IMAV	MAX RNG	AGM
4	Mk 82	30-deg dive	T- AUTO
5	Mk 82	30-deg dive	GAUT
6	Mk 82	30-deg dive	GCIP



TARGETS OF OPPORTUNITY





IHAVS FLIGHT TEST PLAN



EVENT #8 IHAVS-EW THREAT MANAGEMENT



Run	Pass	Direction	System	Route	Threat Array
1	1	Outbound	Non-IHAVS	A	1
1	2	Inbound	IHAVS	A	2
2	1	Outbound	Non-IHAVS	B	3
2	2	Inbound	Non-IHAVS	B	1
3	1	Outbound	Non-IHAVS	C	2
3	2	Inbound	IHAVS	C	3
4	1	Outbound	IHAVS	A	1
4	2	Inbound	Non-IHAVS	A	2
5	1	Outbound	IHAVS	B	3
5	2	Inbound	IHAVS	B	1
6	1	Outbound	IHAVS	C	2
6	2	Inbound	Non-IHAVS	C	3



RESULTS



NON-IHAVS – TACTICAL INGRESS (HUD)



- Workload affected due to increased head-down time
- HUD was a head “magnet”
- Attack tactics driven by limited HUD FOV
- Audio threats required to be cross-checked with visual cues
- One MFD in TAV-8B limited pilot access to information
- HOTAS affected pilot workload (proficiency/PVI)



RESULTS



IHAVS PRE-PLANNED TARGET ENGAGEMENTS (HMD) (GOODS)



- Off-boresight symbology cues resulted in early visual detection of target area
- IVM provided capability to manipulate the IHAVS
- TPOD provided an off-boresight sensor for targeting
- 3-D audio/HMD provided effective audio/visual threat cueing
- ANR resulted in a more quiet cockpit environment
 - Lab results indicated approximately 10-15 dB reduction



RESULTS



IHAVS PRE-PLANNED TARGET ENGAGEMENTS (HMD) (OTHERS)



- “Jitter” and “latency” in HMD distracted overall system operation
- Helmet would shift on pilot’s head - symbology fadeout
- IVM would not recognize or mis-recognize voice commands
- TPOD resolution was poor and target tracks were difficult
- TPOD would break lock during maneuvering



RESULTS



IHAVS TARGETS OF OPPORTUNITY ENGAGEMENTS (HMD) (GOODS)



- HMD provided additional flexible attack options
- HMD symbology provided means of marking/re-acquiring target
- HMD off-boresight attitude/airspeed/altitude cues more useful
- IVM effective for sensor management when working properly
- 3-D audio provided additional threat SA



RESULTS



IHAVS TARGET OF OPPORTUNITY ENGAGEMENTS (HMD) (OTHERS)



- “Jitter” and “latency” in HMD a problem
- HMD symbology not optimized due to project limitations
 - Distinct symbology
 - Clutter off-boresight
- IVM recognition rates degraded during maneuvering



RESULTS



THREAT MANAGEMENT (GOODS)



- Better threat SA
 - Less head-down time
- Localization; 3-D audio with HMD symbology
- Better use of mission cross-check time



RESULTS



NON-IHAVS – WEAPONS DELIVERY (HUD)



- Miss errors were consistent with Fleet AV-8B performance
- TAV-8B provided a stable weapons platform
- HUD presentation was satisfactory for bomb deliveries
- Slew anomalies resulted in degraded GAUT bombing accuracy



RESULTS



IHAVS - WEAPONS DELIVERY (HMD)



- Bombing accuracy could be better with less system “noise”
- Accurate symbology placement was degraded
- Ability to accurately follow steering symbology degraded
- Double imaging and symbology fadeout would occur
- IVM was helpful when working properly



CONCLUSIONS



HMD



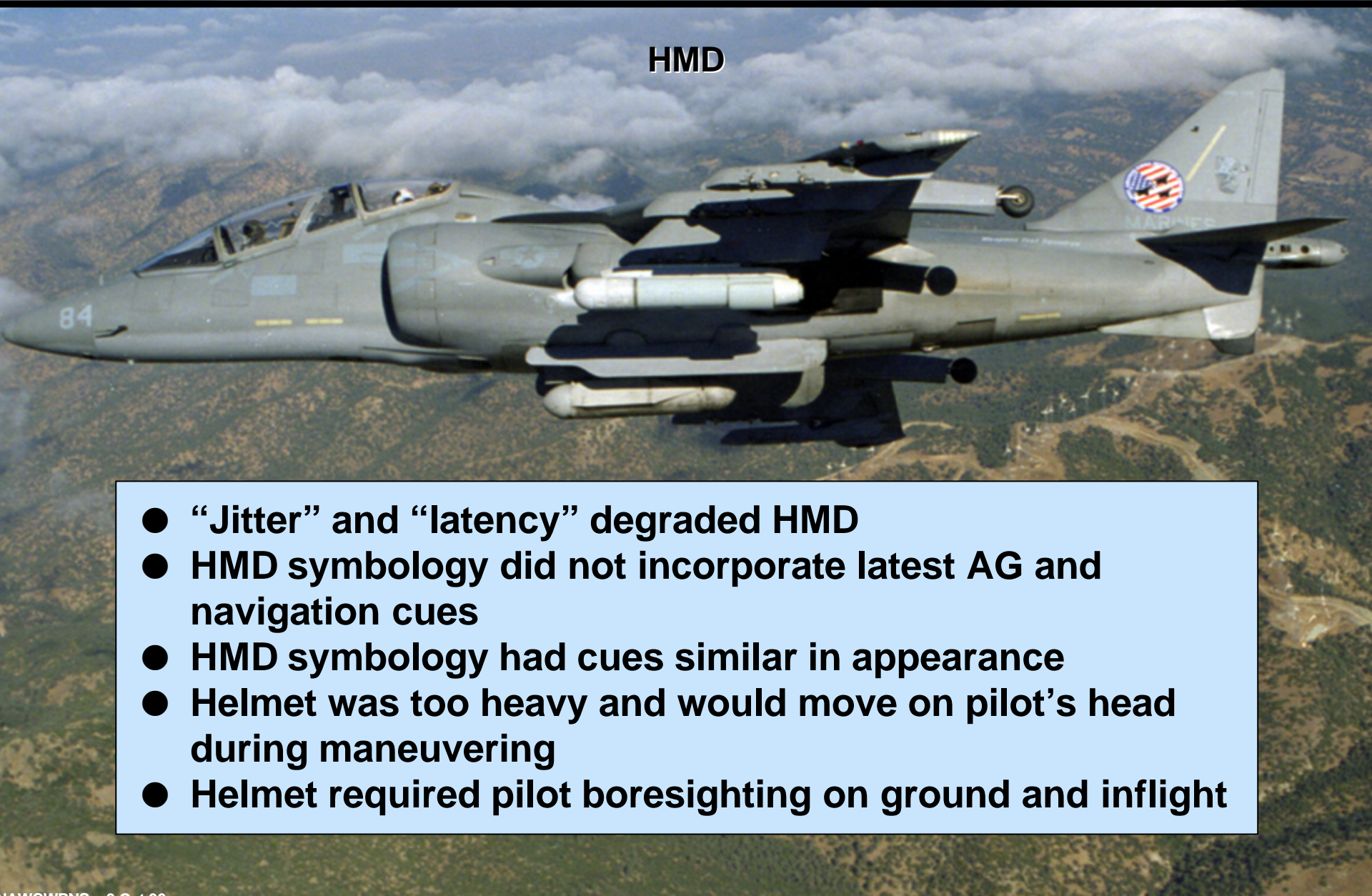
- Off-boresight HMD symbology was greatest advantage
- Off-boresight capability provided more attack options
- Better threat SA was provided using HMD symbology
- Maneuver potential could be quickly assessed using HMD



CONCLUSIONS



HMD



- “Jitter” and “latency” degraded HMD
- HMD symbology did not incorporate latest AG and navigation cues
- HMD symbology had cues similar in appearance
- Helmet was too heavy and would move on pilot’s head during maneuvering
- Helmet required pilot boresighting on ground and inflight



CONCLUSIONS



IVM



- Provided a simple/intuitive means of managing information and sensors
- Words were easily learned compared to mastering a complex HOTAS mechanism



CONCLUSIONS



IVM



- Recognition rate was not reliable enough
- IVM lacked adequate feedback to pilot of activated status
- IVM mis-IDs were far worse than no IVM ID



CONCLUSIONS



TPOD



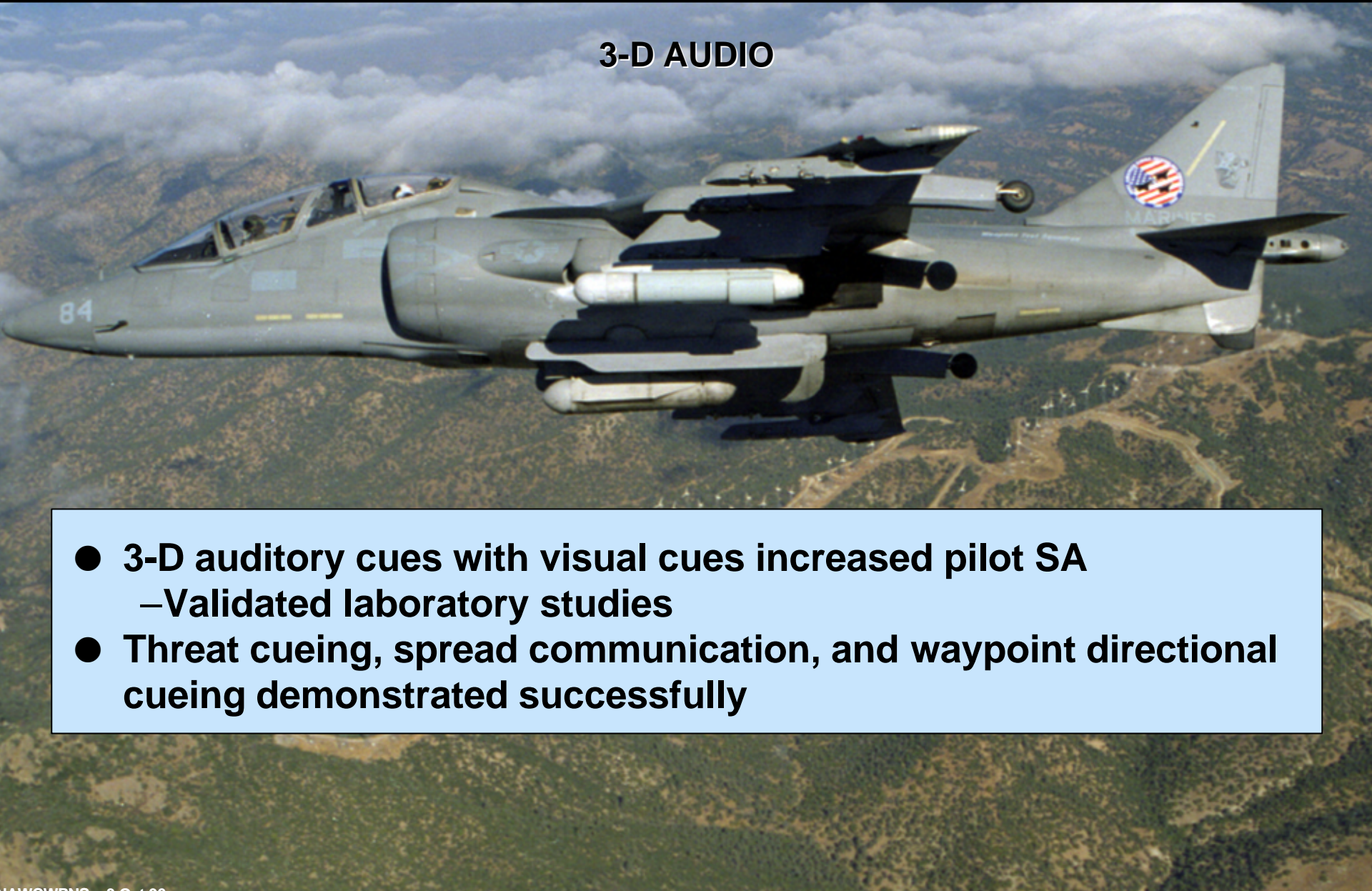
- Provided capability to identify targets and employ weapons off-boresight
- Validated system integration
- Not state-of-the-art targeting pod capabilities



CONCLUSIONS



3-D AUDIO



- 3-D auditory cues with visual cues increased pilot SA
 - Validated laboratory studies
- Threat cueing, spread communication, and waypoint directional cueing demonstrated successfully



CONCLUSIONS



3-D AUDIO



- True 3-D is required to include elevation/azimuth/range to be provided by systems utilizing audio
- System allowed localization of only two threats by pilots



CONCLUSIONS



ANR



- Unwanted background noise eliminated
- Radio and intra-cockpit communications more effective
- Threat tones were clear and precise



CONCLUSIONS



IHAVS



INCREASED SITUATIONAL AWARENESS/DECREASED WORKLOAD

- HMD provided on/off boresight symbology, flight/attitude awareness
- IVM provided simple capability to manage information/multiple sensors
- TPOD provided off-boresight identification and targeting capability
- 3-D audio system with ANR supplemented visual cues



RECOMMENDATIONS



HMD



- “Jitter” and “latency” must be similar to that of HUD
- Symbology requires more study and in-flight evaluations
- HMD capable helmets with the same weight of present day helmets should be developed
- Should not lose symbology during maneuvering
- Should require a simple and reliable boresight capability



RECOMMENDATIONS



IVM



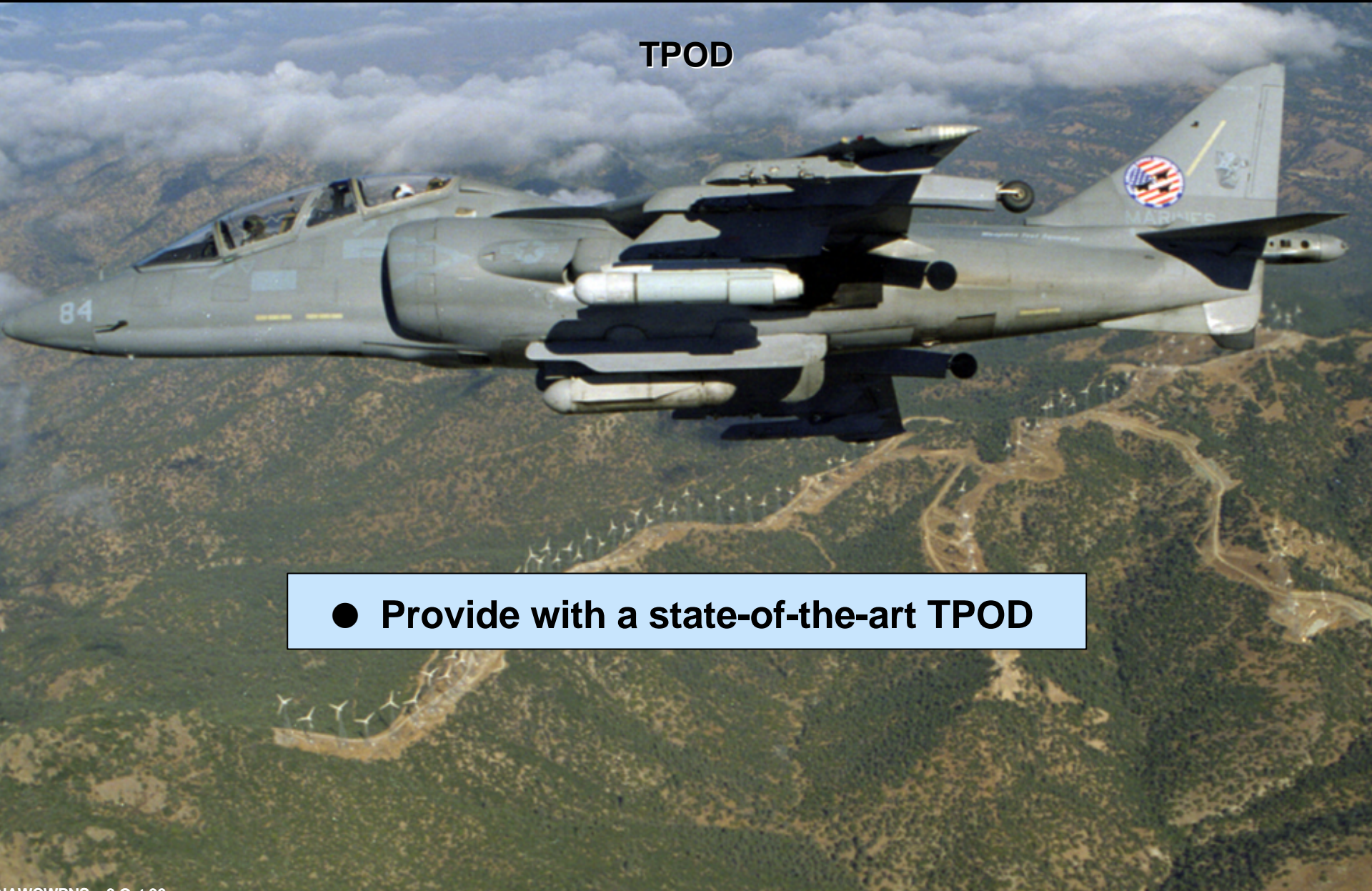
- Develop a simple, robust, and reliable IVM system
 - Larger vocabulary
 - Able to recognize words under different stress, breathing, and g conditions
 - Require minimal pilot training
- Must be as reliable as present day HOTAS switchology



RECOMMENDATIONS



TPOD



- Provide with a state-of-the-art TPOD



RECOMMENDATIONS



3-D AUDIO



- Develop systems capable of supporting 3-D audio (azimuth, elevation, range)
- Continue to develop and evaluate 3-D audio system to improve multiple localization



RECOMMENDATIONS



ANR



- Ready for incorporation



RECOMMENDATIONS



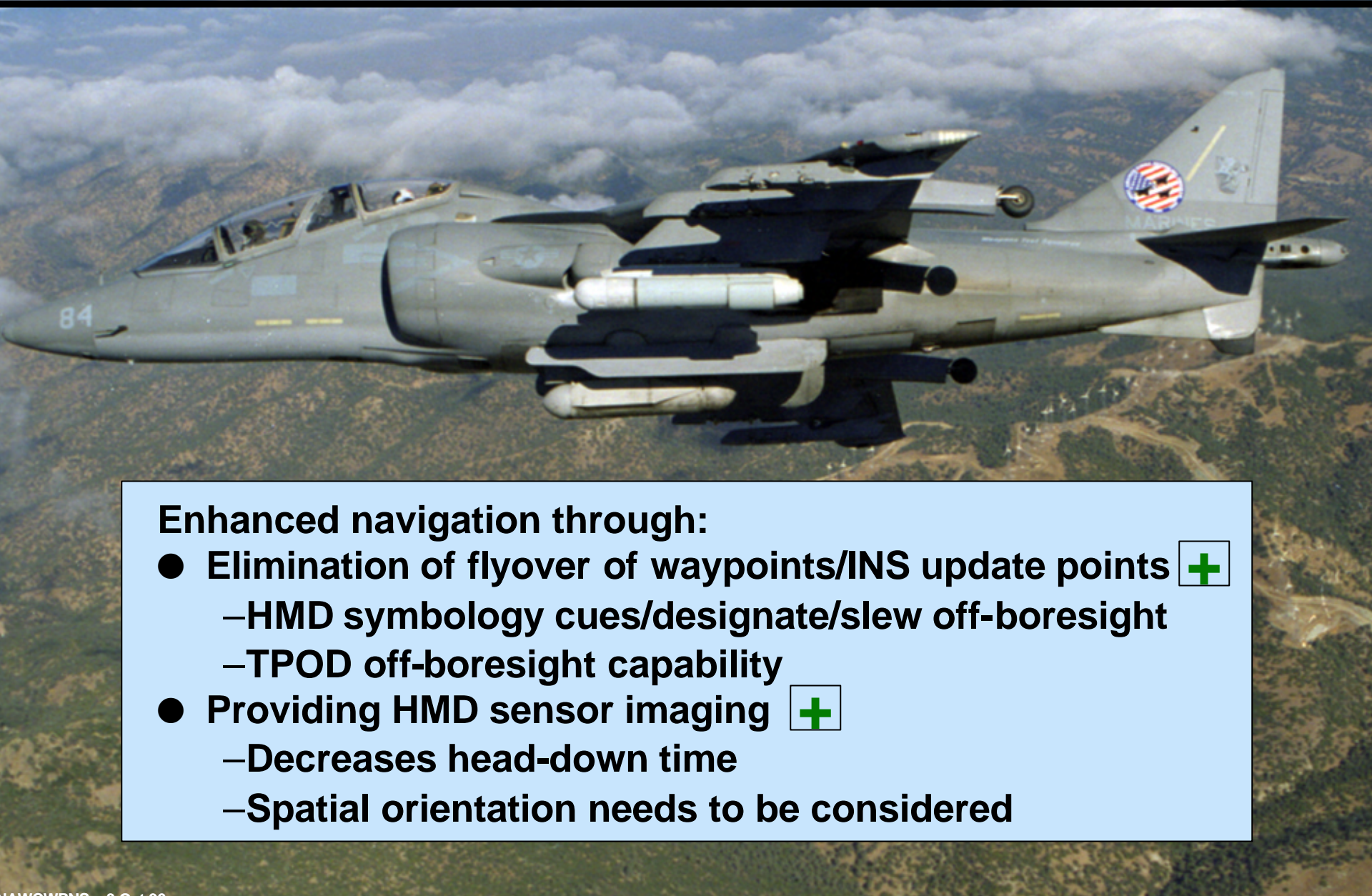
IHAVS





- **Continue supporting development and flight testing of IHAVS technologies**
 - IHAVS increased SA and decreased workload
 - Successful demonstration of IHAVS potential
 - Enhanced air-to-ground mission effectiveness
 - IHAVS is the basis for the next generation human systems interface for the tactical strike fighters of tomorrow



JSF OPERATIONAL BENEFITS



Enhanced navigation through:



- Elimination of flyover of waypoints/INS update points 
 - HMD symbology cues/designate/slew off-boresight
 - TPOD off-boresight capability
- Providing HMD sensor imaging 
 - Decreases head-down time
 - Spatial orientation needs to be considered



JSF OPERATIONAL BENEFITS



Enhanced weapon employment:



- Quicker/easier target acquisition through off-boresight cueing 
 - HMD symbology
 - TPOD limitations (especially mask zones)
- Reduced target designation time through HMD imaging 



JSF OPERATIONAL BENEFITS



Enhanced weapon employment (continued):


- Longer range missile launches 
 - Great potential for JSOW, JDAM, HARM Block 6
- Increased potential for multiple kills per pass 
 - Depends upon OFP capability
 - HMD/TPOD/Radar Symbology



JSF OPERATIONAL BENEFITS



Reduced aircrew workload and increased safety and survivability:






- **Voice control of communication, navigation, IFF, sensor weapon, and countermeasure systems** 
 - Simplicity - HOTAS vs IVM
 - Reliability must be that of HOTAS
 - Data/target/countermeasures/sensor management



JSF OPERATIONAL BENEFITS



Reduced aircrew workload and increased safety and survivability (continued):


- 3-D cueing: threat  ; target info  ; course info 
 - Cross-check requirement is decreased
 - Need true 3-D system
- Potential for continuous display of aircraft performance parameters  / 
 - Symbology needs to be optimized, minimize clutter



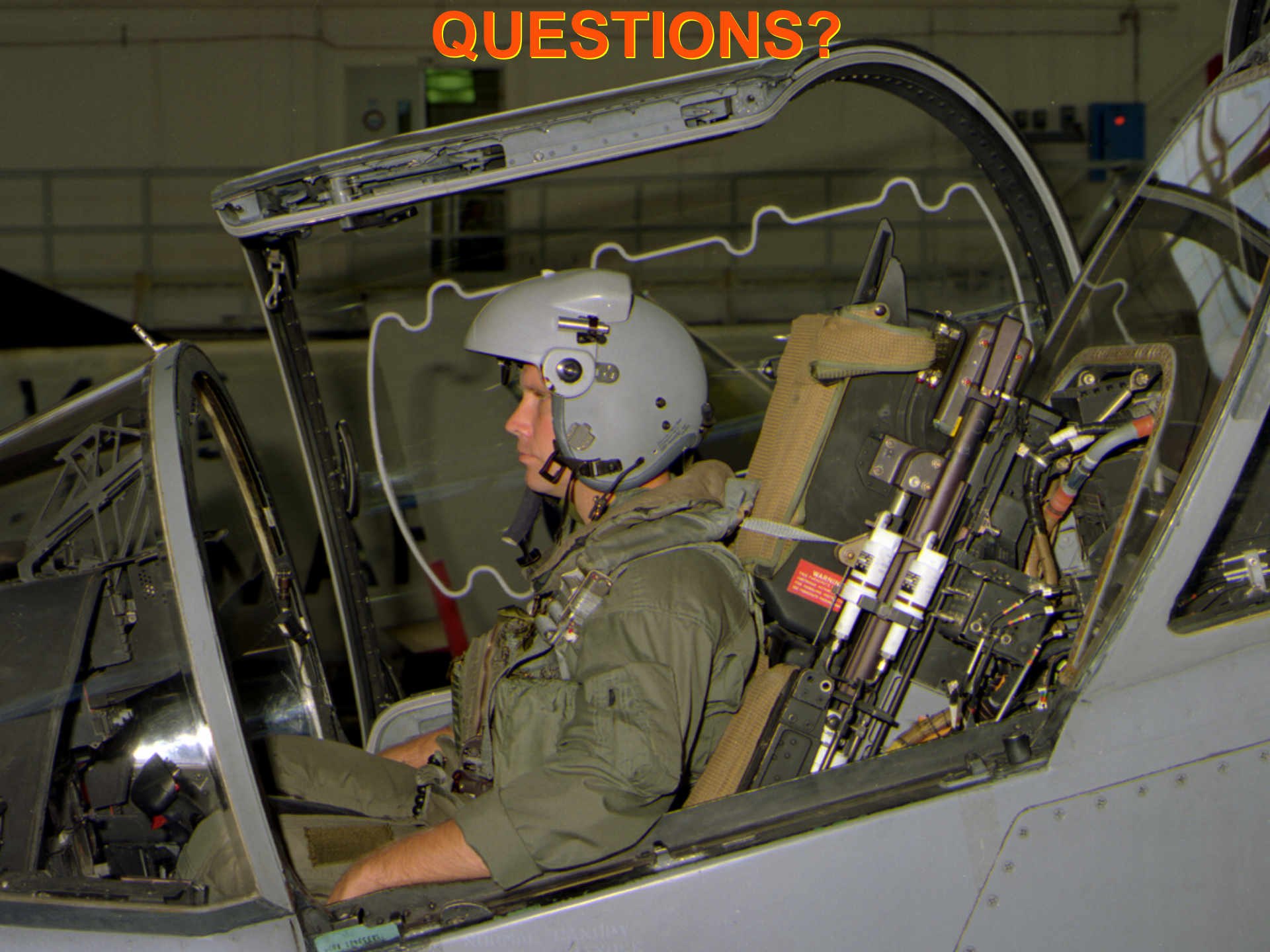
JSF OPERATIONAL BENEFITS



IHAVS increased spatial orientation and tactical SA:

- **Increased mission effectiveness** 
 - System needs refinement
 - What/when/where of attitude references needs to be further investigated

QUESTIONS?





RESULTS



THREAT MANAGEMENT (OTHERS)



- Fixed elevation with azimuth, no range
- Could only clearly separate two threats